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# Agricultural Research

Dietary Copper:
Heart Risk Factor?
Story on page 6

245

# Infant Mortality: One Result of a Deficient Diet

A group of 2- and 3-year-olds carrying plastic buckets and shovels recently gathered in a sandbox to break ground for a new $49 million Children's Nutrition Research Center in Houston. The new building will permit the center, which first opened in 1978, to move from its current rented quarters and double its staff to 50 scientists.

The facility is funded by the Agricultural Research Service and operated by Baylor College of Medicine in cooperation with Texas Children's Hospital. When completed in 1987, the 11-story building will give the United States the finest center in the world for research on the nutritional needs of the young, according to Buford L. Nichols, M.D., the center's scientific director.

Americans have never known the kinds of pervasive malnutrition and hunger that haunt Africa and other parts of the world. But serious problems exist here, too, and researchers at the center will try to find solutions to some of them.

With an infant mortality rate of 11.9 deaths per 1,000 live births in 1981, the United States shared 13th place with Belgium and New Zealand among 41 nations ranked by their infant mortality rates. Although the U.S. infant mortality rate is declining, preliminary figures for 1984 still show a rate of 10.6.

Experts now agree that a close connection exists between diet and health and that dietary deficiencies among pregnant and nursing mothers are a part of our national infant mortality problem. Although most American babies survive the first critical months, they must have adequate diets in their formative years to sustain rapid growth of the brain, muscles, bones, and tissues; to store energy; and to build disease resistance.

Eating right during childhood is particularly important because a poor diet limits forever the physical and mental potential a child can reach. Good nutrition prevents illnesses throughout life, reduces the cost of a person's health care, and helps restrain the rising cost of public health services and private insurance premiums.

A poor diet, not the lack of food, is the chief nutrition problem in this country. The U.S. Department of Agriculture's food stamp, school lunch, and other feeding programs are designed to provide adequate nutrition to the disadvantaged. But even with these comprehensive programs, many children suffer from a deficient diet. Although there are more complex reasons, some parents let their children eat too many junk foods. They ignore or simply do not know the basics of good nutrition: Eat a variety of foods and maintain a reasonable weight. Eat an adequate amount of starch and fiber, and avoid too much fat, sugar, sodium, and alcohol.

Nutrition research, a relatively new but promising area of science, has already brought great improvements in infant formulas and other baby foods. And partly because of new and highly precise laboratory instrumentation and sophisticated techniques that were unavailable only a few years ago, we can expect even more advances soon.

USDA scientists pioneered nutrition research, beginning with the late 19th century work of Wilbur O. Atwater, the father of American human nutrition research. Since then, USDA-supported scientists have steadily and continuously made significant contributions to the knowledge of nutrition.

Improved food products are needed for America to compete effectively with other nations and to retain and expand our domestic and export markets. Unfortunately, many "new" foods on the market have too much added salt, fat, and calories. With better knowledge of the nutritional needs of children and the nutritional content of food products, farmers, ranchers, and food processors can improve the quality of foods they produce. To meet this need, the new center will include a greenhouse and an animal laboratory where human nutrition researchers can integrate their studies with the work of plant and animal scientists.

At present, the center has four key research programs—lactation studies on the dietary needs of nursing mothers and on the constituents of human milk that promote growth and development; weaning studies on timing the introduction of cereals and baby foods to infants; stable isotope studies to track the absorption of food nutrients and the rate of use in the body; and body composition studies on the effects of nutrients on growth and maturation.

Eventually the center's research agenda will include studies on nutritional problems encountered during pregnancy, energy and lipid needs, diet and brain-and-behavior relationships, micronutrient needs, and nutrition during adolescence.

The Children's Nutrition Research Center will add to our understanding of basic dietary needs in the beginning and formative stages of human life. By applying this knowledge to current and future generations, our young people can live longer, more healthful and productive lives.

**Sam Shaffer,** *New Orleans*

# Agricultural Research

Surveys show that 3 out of 4 Americans get too little copper in their diet—and that may be a heart risk factor that deserves much more attention. Story begins on page 6. (0885X940-7)

p.6

p.10

p.13



## DEPARTMENTS




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Editor: Lloyd E. McLaughlin
Assistant Editor: Donald L. Comis
Photography Editor: Robert C. Bjork
Assistant Photography Editor: Anita Y. Rogers
Art Director: Deborah Shelton





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John R. Block, Secretary
U.S. Department of Agriculture

Orville G. Bentley
Assistant Secretary
Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research Service

## New, Stored-Grain Protection—Fenoxycarb

An insect growth regulator, Fenoxycarb, protects stored grain against several kinds of beetles and moths—yet is nontoxic to humans, animals, or plants—according to research reported by Karl J. Kramer, Agricultural Research Service chemist at Manhattan, KS.

Fenoxycarb protects wheat from certain beetle and moth species better than two commercial grain protectants—malathion, against which beetles and moths are becoming resistant, and *Bacillus thuringiensis* (BT), a bacterium with insecticidal properties.

Kramer says Fenoxycarb proved active against the rice weevil, confused flour beetle, lesser grain borer, and Indianmeal moth and still remained active after 2 years of storage.

Offspring of many insect species never get the chance to mature in treated grain. Kramer found in earlier studies with Fenoxycarb that it thwarted growth in 12 species of stored-product beetles and moths.

In a search for materials more potent than malathion, Kramer and biological lab technician Leon H. Hendricks compared the juvenile hormone Fenoxycarb with malathion and BT treatments. They found that Fenoxycarb reduced the insect population by 93 percent, malathion by 83 percent, and BT by 36 percent.

Finally, at the end of the tests in the fall of 1983, when grain samples were graded by the USDA's Federal Grain Inspection Service, the Fenoxycarb-treated wheat was rated U.S. No. 1, compared with malathion-treated wheat graded U.S. No. 2 because Indianmeal moth larvae damaged so many kernels.

Although many chemical insecticides have been screened as potential grain protectants, none has been qualified as toxic to insects, yet nontoxic to animals and plants since malathion, registered in 1958.

Kramer says knowledge of Fenoxycarb's full potential as a grain protectant, however, must await results of additional field tests and long-term toxicological studies.—**Betty Solomon,** Peoria, IL.

*Karl J. Kramer is in USDA-ARS Biological Research, U.S. Grain Marketing Research Laboratory, 1515 College Avenue, Manhattan, KS 66502.* ■

## Winterset Holds Up Against Destructive Virus

A new iceberg lettuce, Winterset, now offers lettuce growers and consumers extra protection against crop losses and price fluctuations resulting from lettuce mosaic virus.

"Once mosaic virus gets hold, it can take over a growing area and stop production for weeks," says Edward J. Ryder of the U.S. Agricultural Research Station, Salinas, CA. Such infections can cause growers to lose an entire crop and drive prices up to consumers.

Winterset is one of the first two lettuce varieties in the United States that are resistant to mosaic virus. Ryder, an international authority on lettuce, developed both varieties.

"Winterset is ideal for winter planting in the desert regions of Arizona and California, as well as early spring planting in California's San Joaquin Valley," according to Ryder. These regions combined produce nearly half of all the lettuce grown in the United States today.

Some protection against mosaic disease is already provided by a seed-screening system that's required by law in most lettuce-growing districts of the two states. Companies that sell lettuce seed must subject the seed to an analysis that indicates if the seed is virus-free.

Farm worker diking furrow-irrigated lettuce field near Salinas, CA. Winterset is one of the first two lettuce varieties in the United States resistant to mosaic virus. (0584X632-17)

Then why the need for a mosaic-resistant lettuce? Ryder explains, "Having one form of protection is good, but having two forms of protection is better."—**Marcia Wood,** Albany, CA.

*Edward J. Ryder is in USDA-ARS Vegetable Production Research at the U.S. Agricultural Research Station, 1636 E. Alisal St., P.O. Box 5098, Salinas, CA 93915.* ■

## Cornstalks Less Likely To Fall Before Harvest

Today's hybrid corn not only yields much better than corn grown in the forties and fifties but also produces stalks that are several times less likely to fall over before harvest.

Downed—or lodged—corn

may not be picked up by mechanical harvesters. If it is harvested, it is more likely than corn from standing stalks to have been damaged by micro-organisms. Farmers who harvest early to avoid late-season lodging find their drying costs increase because the grain contains too much moisture for safe storage.

Larry Darrah, plant geneticist with the Agricultural Research Service, and colleagues with the University of Missouri in Columbia, foresee further breeding improvements in stalk strength.

To evaluate stalk strength, the researchers measured the amount of mechanical force needed to crush a section of mature stalk. Plants with the highest crushing resistance provided seeds for another generation. Stalk strength of an experimental variety of white corn, MoSQA, increased 25 percent per cycle. Stalk strength of MoSQB, a yellow corn, increased 13 percent per cycle.

Lodging decreased 2.8 percent per cycle in MoSQA and 10.7 percent in MoSQB.

The effectiveness of selection in MoSQB was most apparent on heavily fertilized plots, Darrah says. Darrah suggests that as farmers began using higher rates of nitrogen fertilizer since the forties, newer lodging-resistant hybrids were better able to use some of the additional nitrogen to maintain stalk quality. —**Ben Hardin,** Peoria, IL.

*Larry Darrah is in USDA-ARS Crop Production Research, Room 110A, Curtis Hall, University of Missouri, Columbia, MO 65211.* ■

## Psoralens: A Tale of Cosmetics, Livestock, and Butterflies

The ancient Egyptians used psoralens, naturally occurring chemicals that make skin extremely sensitive to the effects of sunlight, to darken unsightly white patches.

The plant commonly called bishops-weed *(Ammi majus)* has been used for several thousand years in the Middle East to treat skin depigmentation. The plant's efficacy depends on the psoralens it contains.

But along with being an ancient cosmetic as well as the drug of choice in the modern treatment of serious skin disorders such as psoriasis, psoralens cause serious problems with livestock.

As a practical and economic matter, say Agricultural Research Service chemists G. Wayne Ivie and Ross C. Beier, veterinarian Loyd D. Rowe, and entomologist Don L. Bull, livestock should be kept away from photosensitizing plants (plants that make the skin very sensitive to sunlight) as much as possible.

Bishops-weed has been implicated as a livestock photosensitizer in Texas, as has blisterweed *(Thamnosma texana).* Livestock that eat these plants suffer blistering, peeling of the skin, and even blindness. They seldom die; but for obvious reasons, the symptoms can cause serious economic losses, Ivie says.

While they were in the field collecting plants for their blisterweed studies, the scientists observed caterpillars of the black swallowtail butterfly feeding on the toxic plant in direct sunlight. How these insects could avoid being poisoned by the plant aroused their curiosity and they collected some of the larvae for study. After the collecting, rearing, and all the laboratory housekeeping that goes into such a study, they learned that the black swallowtail butterfly has a tremendous capacity to detoxify psoralens. Theirs is the first report of this type of detoxification which has the effect of rendering safe an otherwise highly toxic food source.

"For instance, the capacity of the butterfly caterpillars to detoxify psoralens, primarily in the midgut of the insect, is about 50 times greater (or 5,000 percent) than that of an insect we used for comparison—the fall armyworm. Such findings are important in showing how certain insects adapt to the toxic components that occur naturally in their food. The detoxifying mechanism defined here may contribute to a better understanding of insect and plant relationships that involve important crops and major destructive insects," Ivie says.

He speculates that the black swallowtail butterfly has maximized a metabolic process that occurs in other butterflies and moths, giving it a competitive advantage over other insects that find psoralen-containing plants toxic and unpalatable.—**Bennett Carriere,** New Orleans, LA.

*G. Wayne Ivie, Ross C. Beier, Loyd D. Rowe, and Don L. Bull are in the USDA-ARS Veterinary Toxicology and Entomology Research Laboratory, P.O. Drawer GE, College Station, TX 77841.* ■

## Mother's Milk Protects Infants

A mother's milk, depending on where she lives, can protect her baby from locally prevalent harmful bacteria.

It is not clear, however, whether infants acquire immunity to these bacteria passively from the milk or whether unidentified agents or conditions trigger their immune systems. Agricultural Research Service studies underway to answer this question will use tracers in mother's milk fed to infants to find the exact source of this necessary immunity.

Results may also shed light on why children of malnourished mothers don't grow as fast as those whose mothers are well nourished.

*Cutberto Garza, who is leading this research, is associate scientific director of the USDA Children's Nutrition Research Center, 6221 Fannin St., Houston, TX 77030.* ■

245

# Copper: A Missing


Above: Electrocardiogram (EKG) measures electrical activity in the heart of a copper-deficient rat. Brenda Skinner, at Grand Forks, ND, monitors EKG. (0885X926-32)

Right: Chemist Terrence Shuler, at Grand Forks, ND, analyzes rat tissue samples for copper. The copper content of tissues reflects the level of copper in the diet and indicates if rat was copper deficient. (0885X927-28A)

Evidence is mounting that marginal copper intake may contribute significantly to coronary heart disease—the number one killer in the United States.

Studies done over the last 13 years at the Agricultural Research Service's Grand Forks Human Nutrition Research Center in North Dakota and more recently at the Beltsville Human Nutrition Research Center in Maryland show that animals fed diets deficient in copper develop most of the symptoms known to increase risk of coronary heart disease.

Leslie M. Klevay, research leader at the Grand Forks center, has analyzed and studied the effects of copper deficiency on mice, rats, rabbits, pigs, and three species of monkeys. When severely deprived of copper, these animals developed abnormal electrocardiograms, elevated blood cholesterol, and impaired ability to metabolize glucose, he said. They also developed high levels of triglycerides and uric acid—symptoms widely believed to increase risk of heart attack.

Klevay, who holds both an M.D. and a doctorate in hygiene, contends that copper deficiency is "a major contributor to the development of ischemic [coronary] heart disease."

According to recent surveys, only 25 percent of the U.S. population consumes the 2 milligrams of copper a day estimated to be adequate by the Food and Nutrition Board of the National Academy of Sciences. Typical diets in the United States provide about half that amount, and some diets here and in other industrialized countries contain only 0.8 milligram daily.

The animal diets were two to three times more deficient in copper than the typical U.S. diet, Klevay says.

During the studies, many of the animals died suddenly, he says, often from ruptured hearts. Autopsies showed that their hearts and arteries had abnormal connective tissue, fat deposits, and inflammation.

# Link in Coronary Heart Disease?

These findings are corroborated by studies with rats at the Beltsville center. "Hearts and blood vessels in animals with copper deficiency have abnormal anatomy, chemistry, and function," says Meira Fields, a research associate from Georgetown University's Medical School studying copper metabolism at Beltsville under a cooperative agreement.

Although the findings have been published in scientific journals, she says, "the consequences of inadequate copper intake have not yet been recognized by the medical community or the general public."

Why is copper good for the heart? Klevay believes it essential in the manufacture of the three major types of connective tissue found in the heart and arteries. Research has already established that copper is an integral part of enzymes involved in the production of collagen—the fibrous component that binds heart muscle cells together—and of elastin—the component that makes heart and artery walls elastic, he says.

Foods rich in copper include liver, oysters, chickpeas, nuts—especially brazils and cashews—and seeds, with poppy and sunflower seeds at the top of the list.

Studies are now underway at the Grand Forks center to determine if a moderate copper supplement has the same beneficial effect as copper in the diet.

James C. Smith, Jr., chief of the Vitamin and Mineral Nutrition Laboratory at Beltsville, cautions about supplementing diets with copper because "there is a relatively narrow range between safe and toxic for copper." Studies show that 10 to 15 milligrams of copper a day can be dangerous to humans.

According to Klevay, copper deficiency can also be caused by a high intake of zinc or other substances that interfere with the body's use of copper. Preliminary findings point to vitamin C as one of these substances.

Smith says that normal levels of zinc in a well-balanced diet do not upset the balance, but excessive or unnecessary zinc supplements can cause a problem.

The Beltsville scientists are also finding that diets high in certain sugars interfere with rats' absorption of copper, whereas high-starch diets do not.

Fructose and other sugars that contain fructose—such as sucrose (table sugar)—markedly increase the severity of copper deficiency in rats, according to Sheldon Reiser, chief of the Carbohydrate Nutrition Laboratory.

"The concern here is that U.S. diets contain relatively high levels of sucrose," Reiser says. "And the amount of fructose in the U.S. food supply has increased at least *sixfold* since high-fructose corn sweeteners were introduced in 1970. Fructose now constitutes about 10 to 12 percent of total calories consumed."

Coronary heart disease has been associated with nearly 250 different factors during the 200 years it has been studied, says Klevay. The most widely accepted theory assumes that the amount of saturated fats and cholesterol in the diet affects the amount of these substances in the blood, which, in turn, contributes to the risk of coronary heart disease.

Klevay, however, believes that copper deficiency could be the single most important factor among dietary causes.

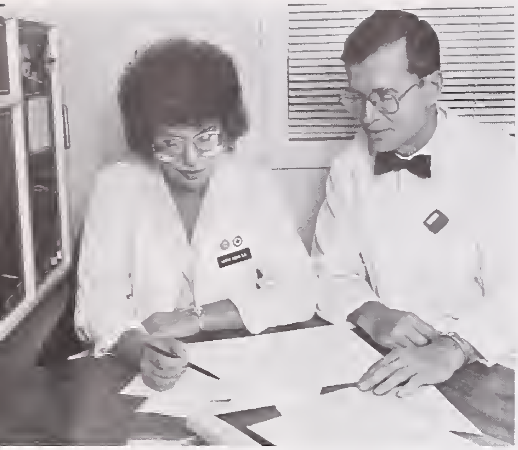
The Beltsville researchers consider copper deficiency only one of several factors that may contribute to coronary heart disease—but one that definitely warrants much more attention.

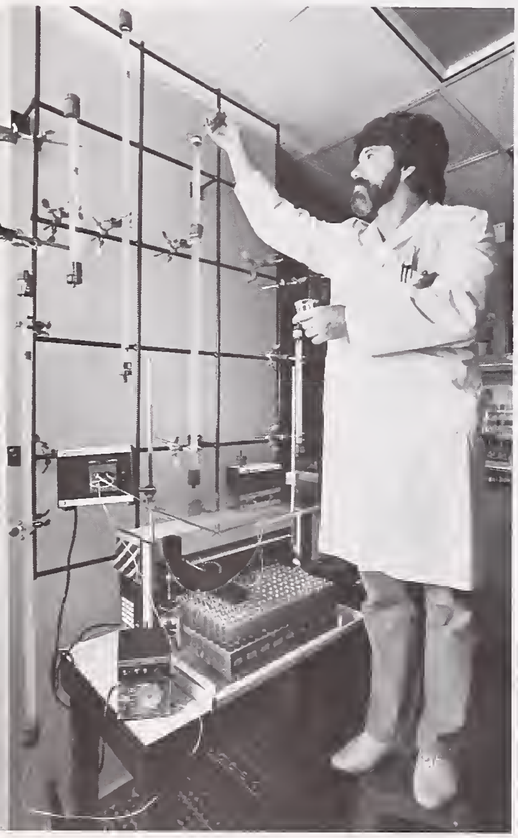
"There are many interactions among dietary components in the body that are not well understood," Reiser explains. "Some people are genetically predisposed toward high blood cholesterol and difficulty in metabolizing glucose. Also, a person's sex, age, and eating habits—whether they nibble or gorge—all contribute to risk."

Top: Sheldon Reiser, chief of the ARS Carbohydrate Nutrition Laboratory in Beltsville, MD, and nutritionist Charles Lewis study data on how glucose and fructose affect copper absorption. (0885X925-30A)

Above: To determine how carbohydrates in the form of glucose and fructose affect copper absorption, Meira Fields, a cooperating research associate, feeds rats specific carbohydrates containing known amounts of radioactive copper. Rat tissues are then placed in a scintillation counter that detects and counts radioactivity in each sample. (0885X914-16A)

## Copper: A Missing Link in Coronary Heart Disease?





Top: Leslie M. Klevay, research leader at the Grand Forks Human Nutrition Research Center in North Dakota, and Kathy Henn discuss characteristics of 24-hour cardiogram performed on a human volunteer in a low-copper study. (0885X900-15)

Above: Thomas L. Starks, an ARS postdoctoral research associate at Grand Forks, ND, separates protein from wheat labeled with a stable copper isotope, using column gel chromotography. This study may help determine what kind of protein or other chemical constituent of food copper attaches to. (0885X926-23)

As part of studies on human dietary requirements for copper, ARS chemist Phyllis E. Johnson, at Grand Forks, ND, measures amount of stable copper isotope absorbed from foods eaten by volunteers. (0885X926-13)

Klevay has found links between copper deficiency and a high-fat diet. "Foods high in fat generally have high ratios of zinc to copper. And diets designed to lower serum cholesterol, which decrease fat and cholesterol and increase polyunsaturated fat, tend to have lower ratios of zinc to copper," he says. "Moreover, polyunsaturated fat seems to decrease retention of dietary zinc without affecting the retention of copper."

Children who have Menkes' disease, a hereditary inability to absorb dietary copper, also have high levels of fats and cholesterol in their blood and glucose intolerance, Klevay notes. Also, studies have shown that when rats have had their serum cholesterol artificially elevated, extra copper in the diet will bring it back down.

More recently, Klevay has found that adding adequate amounts of copper to the food of mice on a high-fat diet can prevent blood clots

# Isotopes Track Trace Minerals

New, more accurate information about the amounts of minerals people absorb from food is coming from studies using "tracers" of these minerals and high-precision instruments to track them.

The experiments will help nutritionists find out how much of these minerals people need to prevent health-threatening deficiencies.

Even though minerals such as copper, iron, zinc, and manganese are needed in only very small amounts, deficiencies may lead to conditions ranging from retarded growth (in the case of zinc) to increased risk of heart disease (reported in animal studies of copper deficiency), says Judith R. Turnlund of the Western Human Nutrition Research Center, San Francisco.

Turnlund uses rare—lighter or heavier—atoms (isotopes) of these minerals as tracers, distinguishing them from other atoms with an instrument that separates atoms by weight. She adds these tracers to the diets of volunteers. Unlike radioactive isotopes, these stable isotopes are perfectly safe, even for pregnant women.

Any of the tracer that isn't absorbed by the body from these isotope feedings will move out through the intestines. A sample of the mineral being studied is removed from waste material and analyzed to calculate how much each volunteer absorbed.

So far, this technology has provided such findings as:

- High levels of phytate—a natural ingredient in whole grains, green beans, and other common foods—may inhibit the body's ability to absorb zinc. Young men who ate diets high in phytate absorbed only one-half as much zinc as when they were put on diets free of phytate.
- Zinc and copper absorption may be enhanced during pregnancy. When fed similar diets, pregnant women tended to absorb slightly more zinc and significantly more copper than other women. The findings suggest that the special Recommended Dietary Allowance (RDA) of zinc for pregnant women—which is significantly higher than the RDA of zinc for other women—may need to be adjusted and that the change in copper metabolism during pregnancy should be taken into account when setting the allowance for copper.—**Marcia Wood,** Albany, CA.

*Judith R. Turnlund is at the USDA-ARS Western Human Nutrition Research Center, Bldg. 1110, Rm. LR3142, Presidio, San Francisco, CA 94129.* ■

in the heart and other profound cardiovascular damage. High-fat diets were found to induce severe damage to the heart and vessels as long as 20 years ago, leading to the current concern over the fat content of human diets.

Few human studies on copper deficiency have been done. In a 6-month study at Grand Forks, one healthy 29-year-old man received a diet containing 0.8 milligram of copper a day—about the same amount of copper as some people in the United States were found to consume. While on the low-copper diet, his blood cholesterol steadily increased from 202 to 234 milligrams per deciliter (mg/dL). When adequate copper was added to the diet, his blood cholesterol steadily dropped to 198 mg/dL. The American Heart Association recommends maintaining blood cholesterol below 200 mg/dL.—**Judy McBride,** Beltsville, MD.

*Leslie M. Klevay is at the USDA-ARS Human Nutrition Research Laboratory, P.O. Box 7166, University of North Dakota, University Station, Grand Forks, ND 58202. Sheldon Reiser and James C. Smith, Jr., are at the USDA-ARS Beltsville Human Nutrition Research Center, Building 307, Beltsville, MD 20705.* ■

# Weed Problems Could Be Solved By "Seedicide"

Crops have been cultivated for some 10,000 years, but people have yet to conquer the source of their weed problems—the dormant weed seed.

That may change.

Two Agricultural Research Service scientists have discovered that methyl isothiocyanate, or MIT, can kill weed seeds before they have a chance to sprout.

The discovery could drastically reduce the use of hoe or herbicides on horticultural crops, according to plant physiologists John R. Teasdale and Raymond B. Taylorson at Beltsville, MD.

Methyl isothiocyanate is the active compound in several all-purpose pesticides that have been used by vegetable and turf farmers for years to control fungi, insects, nematodes, and weeds. It is not the chemical reportedly involved in the recent disaster in Bhopal, India—methyl isocyanate MIC.

Until now, no one had shown that MIT was a "seedicide," says Teasdale. "Most herbicides kill only the small fraction of weed seeds that germinate each year," he explains, "but MIT directly kills dormant seeds." Exceptions are seeds with a hard coat, such as velvetleaf, morningglory, bindweed, and some legumes.

Seed-killing methyl isothiocyanate kept crabgrass seeds *(Digitaria sanguinalis)* in flask on right from germinating. One week after the seeds were placed in flasks the untreated crabgrass seeds in flask on left have germinated. (0885X936-3)

Environmentally speaking, MIT degrades rapidly in the soil, usually within a few days.

An enormous reservoir of dormant weed seeds in the topsoil is the source of the weeds that plague farmers and homeowners year after year. Some seeds can remain dormant in soil for as long as 100 years. Cultivated land harbors tens of millions of weed seeds per acre in the top 6 inches of soil, says Taylorson. About 5 to 10 percent emerge each year.

A thorough application of MIT to the topsoil before planting could kill most of these weed seeds, practically eliminating weed problems. Before the "seedicide" can be effective, however, the pesticide industry will have to develop methods for dispersing it evenly throughout the cultivated layer of soil, say the scientists.

For vegetable farmers, for example, the use of herbicides would drop from frequent spraying to occasional spot treatments to clean up weeds from seeds carried in by wind, wildlife, and contaminated irrigation water or drop seeds, says Taylorson.

MIT would probably be too costly for corn, soybeans, and other field crops, Teasdale says, but a more active compound might be economically feasible. He emphasizes that MIT is only one of a larger group of chemically related isothiocyanates that may include compounds lethal to weed seeds at lower rates.

Moreover, many plant species, such as papaya and those in the mustard family, produce their own isothiocyanates and these plants have some capacity to suppress weeds. He recommends that a search of isothiocyanate-producing plants be made to identify the top suppressors. Using these plants as cover crops "may offer interesting possibilities for weed management," he says.—**Judy McBride,** Beltsville, MD.

*John R. Teasdale and Raymond B. Taylorson are at the Weed Science Laboratory, Rm. 27, Bldg. 001, Beltsville Agricultural Research Center-West, Beltsville, MD 20705.* ■

245

# Trace Minerals Move Slower When Plant's Roots Get Cold

Chilly soil can reduce the level of zinc and other trace minerals in plants, so people get less in their diets.

Crops dislike "cold feet," so even a slight drop in soil temperature slows down the uptake of minerals by roots, say David L. Grunes, soil scientist, and Ross M. Welch, plant physiologist, both with the Agricultural Research Service in Ithaca, NY. Grunes says, "New laboratory studies show cold soils keep taproots from penetrating deeply and putting out a thick network of branch or side roots in the lower depths to absorb minerals."

When soil temperatures hover around 50°F, consumers may get less than expected amounts of minerals in foods.

This happens because a smaller root system cannot fully do the work of supplying mineral nutrients to the plant, Grunes and Welch say. "We're doing root research because agriculture has a wealth of information about what happens within plant parts above ground, but relatively little is known about what goes on in the tangled world of roots. Yet, roots are the critical point in the plant's ability to absorb nutrients, water, and essential ions," Grunes says.

So far, Grunes and his colleagues have studied mineral uptake by such grain crops as corn, barley, and wheat, but future research will involve other crops.

As an example of what can happen, he pointed to North Dakota field studies several years ago of corn grown on soils low in zinc and phosphorus. Grunes found that the plants, grown on cold soil, had stunted roots and showed severe symptoms of deficiency in both zinc and phosphorus.

An agency research team in Ithaca has similarly shown in recent greenhouse work that barley plants have much less zinc in their tops when the root-zone temperature is low. Ironically, when the root-zone temperature is low, more zinc is absorbed by the roots, but it stays in root cells.

When the root-zone temperature increases, greater amounts of zinc can travel into the top or edible parts of the barley plant, according to the findings of ARS scientists Grunes, Welch, Earle E. Cary, and Wendell A. Norvell and visiting soil scientist Samuel M. Schwartz of the Volcani Center, Bet-Dagan, Israel.

In its barley studies, the team also found that at a soil temperature of 68°F, the plants produced many branched roots which fanned out and filled their 6-inch-deep containers.

By contrast, at 50°F, the barley plants put forth only a few long, thick roots with some hairlike rootlets. Branching was confined to the older parts of roots in the upper 3 inches of soil, Grunes says.

Knowledge of how and when zinc moves into the food chain is important because it is an essential element. Evidence points to borderline deficiencies in livestock and some human population groups.

Plants need only about 20 parts per million of zinc in their tissues, but animals and humans need more—about 30 parts per million—in their diets.

To complicate matters, plants may achieve excellent growth, yet produce crops lacking in sufficient zinc to meet the nutritional requirements of consumers.

A temperature-related "gatekeeper" role for zinc was found in recent research by Welch, Grunes, and Cary and plant nutritionist John S. Loneragan of Murdoch University, Australia. Zinc regulates the passage of phosphorus in and out of plants through root membranes.

When zinc in soil is low, Welch says, toxic amounts of phosphorus can enter a wheat plant, killing its leaves. Studies showed this phenomenon intensifies as soil temperatures rise.

Farmers can prevent such problems by adding zinc fertilizer to zinc-deficient soils, Welch and Grunes say.

"Finding out exactly what low soil temperatures do to the uptake of such elements as zinc and phosphorus," they say, "could lead to new fertilization strategies."

"For example, to ensure early growth, fertilizers with higher rates of zinc and phosphorus could be tailored for application in spring or fall, perhaps for seasonal soil-temperature patterns of entire ecological zones."

These studies are sponsored by the Center for Root-Soil Research established by ARS, the New York State College of Agriculture and Life Sciences, and the Boyce Thompson Institute for Plant Research at Cornell University.—**Russ Kaniuka**, Beltsville, MD.

*David L. Grunes and Ross M. Welch are in USDA-ARS Plant, Soil, and Nutrition Research at the U.S. Plant, Soil, and Nutrition Laboratory Building, P.O. Box 849, Ithaca, NY 14853.* ■

245

# Little-Known Fly—Promising Biocontrol Weapon

Above: Entomologist Harry R. Gross sprays a hydroxyethyl cellulose solution containing parasitic maggots *(Archytas marmoratus)* against fall armyworms in corn. (0885X873-11A)

Top right: Living maggots in hydroxyethyl cellulose solution (about 10 per drop) are pipetted onto paper caps for cups containing corn earworms. (0885X872-26)

A 1/2-inch-long fly, so little known that it has no common name, is a promising natural weapon against insect larvae that devour millions of dollars' worth of food, feed, and fiber crops. "I venture this prediction because we've learned how to produce the fly on a large scale in the laboratory," says entomologist Harry R. Gross.

"We've known for a long time that the fly—*Archytas marmoratus*—is a parasite of corn earworms and fall armyworms. Now we'll be able to rear enough to explore its use as a practical biocontrol agent," he says.

The fly is found in the southern United States and parts of Central and South America, according to Gross. Its larval stage, a maggot, invades the bodies of these voracious plant-eating worms, preventing them from developing into moths that would ordinarily produce more generations of the larval pests.

In preliminary studies at Tifton, GA, the population of the subsequent moth generation was significantly reduced after Gross and fellow Agricultural Research Service entomologist Orrey P. Young released flies into cages enclosing worm-infested corn plants.

Unlike some flies, such as the common house fly, Gross says *A. marmoratus* does not generally lay eggs. Instead, the female deposits

miniscule maggots—as many as 2,800 during her 50-day life—at sites where worms are feeding. "A major problem that my biological technician, Raydene Johnson, and I had in developing a rearing technique was devising methods to collect the specklike maggots and transfer them to a living rearing medium, specifically corn earworms," he says.

"Briefly put, we take mated females from our fly colony and homogenize them with water in a blender. This ruptures their uteruses, releasing the maggots unharmed. Then we strain the solution to separate the maggots from the fly remains.

"To rear flies, we suspend the maggots in a thicker solution that we dispense with a medicine dropper onto the inside of caps for cups containing corn earworms. When the worms touch the maggots, the maggots burrow in and eventually develop into flies. We can produce up to 100 flies from one female with this method."

In the wild, corn earworms (or fall armyworms) are, of course, feeding on plants when the maggots invade them. The worms finish their growth, leave the plants, and enter the soil to pupate.

During this time, when the pupae would normally be transformed into moths, the maggots begin their development, using the moth pupae for food. Then they too pupate, to emerge from the soil later as flies. As Gross sums it up, "Here you have potential moths entering the soil in their larval form, but harmless flies coming out—harmless, that is, except to destructive insects."

The flies generally mate during their first day of life, and the females begin to deposit maggots 10 days later, thus beginning the cycle again.

Gross's research will concentrate on exploiting the fly's parasitic life cycle. "We have to find out if it is more effective to release the maggots or the flies, and also where, when, and how the releases should be made," he says. "In recent tests, we got good results by applying the maggots on infested corn plants in the same manner as pesticides. We will also try applying maggots in irrigation water, in the same way that fertilizers and pesticides are often delivered to crop plants. The idea is to increase the fly population to the point where it reduces the moth population to an economically unimportant level. Results so far lead me to believe that *A. marmoratus* could supplement chemical control of these pests."—**David Pyrah,**
New Orleans, LA.

*Harry R. Gross is at the USDA-ARS Insect Biology and Population Management Research Laboratory, Tifton, GA 31793.* ■

Top: Male and female flies *(A. marmoratus)* are paired and held within a 33- by 33- by 18-centimeter plyboard, screen, and plastic cage at 26°C during the 10-day period before females deposit maggots. (0885X871-30)

Middle: Maggot of *A. marmoratus* fly enlarged about 240 times. Scanning electron micrograph by Thelma (Pat) Carlysle, USDA-ARS, Gainesville, FL. (PN-7188)

Bottom: Fifth-instar corn earworm *(Heliothis zea)* is unwitting host for maggots being raised for release in field. (0885X872-33)

## The Billion-Dollar "Worms"

Experts agree that the corn earworm is one of the most destructive agricultural pests known. Also called the cotton bollworm, tomato fruitworm, and soybean podworm, these widely distributed moth larvae feed on other important crops, including sorghum, peas, beans, and peanuts. One estimate puts the cost of destroyed crops, plus the cost of controlling the worms, at nearly $1 billion a year in the United States.

The fall armyworm is primarily a late-summer pest in the Southeast, according to ARS entomologist Harry R. Gross. "It feeds mostly on grasses, and botanically, corn is a type of grass," he says. "Fall armyworms are one of the chief reasons that two successive corn crops aren't grown every summer in this part of the country."

Gross says the armyworm periodically arrives on the scene early, with devastating results. "When this last happened, in 1977, losses and costs of control on all crops exceeded $137 million in Georgia alone."—**D.P.** ■

245

# Best Wheat Floats to the Top

Researchers often borrow techniques and methods from other scientists—and then improve them. And this is how a simple way to find high-protein wheat seeds came about.

C. James Peterson, an agronomist with the Agricultural Research Service in Lincoln, NE, and University of Nebraska cereal chemist Paul J. Mattern modified a solution-flotation technique originated by A. Garzon-Trula, a scientist for Spain's Ministry of Agriculture. Garzon-Trula's technique used a highly toxic carbon tetrachloride and hexane solution to separate high- and low-protein seeds.

These materials were touchy to work with and required extra safety precautions. Mattern, however, found that similar results were possible by replacing the toxic materials with cold water and two common ingredients—sugar and salt.

Mattern soaked winter wheat seeds in water at slightly above freezing temperature for 9 to 10 days. The protein in the seeds absorbed five times more water than the starch did. The seeds were then placed in a solution of 24 percent sugar and 21 percent salt. Because they had absorbed more of the water in the previous soaking, the high-protein seeds floated to the top—to be scooped off, dried, and planted, if desired.

The researchers planted 61 batches of seed, comparing the wheat grown from flotation-selected, high-protein seed with wheat grown from the original population.

In 12 of 61 cases, the seed selected for higher protein produced wheat in the next crop with about a 1-percentage-point increase in protein content. The average total protein content of hard red winter wheat, for example, is 12 percent.

Interference from nongenetic factors, which is a common problem in field selection tests, was responsible for the low number of cases of protein increase, Peterson says.

Paul J. Fitzgerald, ARS plant germplasm adviser and chairman of the National Plant Germplasm Committee, says, "This technique may be a significant advance for wheat breeders because it is nondestructive and allows them to select for protein content of individual seeds. It will help to maintain or improve protein content while increasing yields, which has always been a difficult challenge." The National Plant Germplasm Committee is a group of federal, state, and industry representatives that coordinates a network of public and private research units and organizations working together to collect, catalog, evaluate, maintain, distribute, and preserve plant genetic material.

"The influences of genetic and nongenetic factors on protein are not identifiable by the solution-flotation technique," Fitzgerald says. "To be sure, caution will be necessary to ensure that when we select for high protein we are not also selecting for an undesirable trait such as disease or insect susceptibility. But because with this method we generally start with a base population already selected for many desirable traits, the odds are favorable that high-protein types will not possess traits that could also be detrimental to our crop improvement efforts."

"Manipulating the solution-flotation method is like fine-tuning a microscope or focusing a camera. Adjustments can be made to obtain a better result. By making the solution thinner or thicker, we can determine the size of the sample that will be saved. If we choose, we can save only the top 1 percent of the population that represents the best high-protein types," Fitzgerald says.

The simplicity of this technique makes it ideally suited for developing countries where laboratory facilities are limited or nonexistent.

Looking for high protein was not always so simple, Fitzgerald recalls. Early on, scientists depended on the Kjeldahl method to calculate protein content based on nitrogen content of samples. The Kjeldahl method gives good results, but it's slow and costly and requires the use of specialized equipment and toxic chemicals. The method also requires grinding and destroying the seed.

With the flotation technique, high-protein seeds are safely and inexpensively identified and left intact to germinate and produce high-protein lines for further varietal improvement. While it doesn't eliminate the need for the Kjeldahl method, it does improve the chances of identifying high-protein wheat.—**Linda Cooke-Stinson,** Peoria, IL.

*Paul J. Fitzgerald is at the USDA-ARS Northern Regional Research Center, 1815 N. University St., Peoria, IL 61604. C. James Peterson is in USDA-ARS Wheat Research, University of Nebraska East Campus, Lincoln, NE 68583.* ■

245

# Scientists Attack Rust With Resistance and Biocontrol

Plant scientists in Beltsville, MD, are attacking bean rust, a fungal disease of bean plants, from two natural angles—resistance and biological control.

"Bean rust is the most economically serious leaf disease of edible beans, costing farmers up to $250 million yearly," says J. Rennie Stavely, a plant pathologist with the Agricultural Research Service in Beltsville. "No bean—snap or dry (like kidney and pinto)—escapes the disease." Stavely and fellow pathologist C. Jacyn Baker, are trying to find natural ways to combat bean rust so that farmers can reduce the financial and environmental costs of using chemical fungicides.

"Breeding for resistance in the various types of beans," Stavely says, "is the most effective control. Then, all the farmers have to do to stop rust is plant the resistant variety."

So far, scientists have found many varieties that resist 1, 2, or even more of the 28 most damaging races of rust. But breeders have faced one problem persistently—a variety can resist one race and be completely susceptible to other races. "Every time breeders think they've found a resistant bean, a new, pathogenic race of the fungus seems to pop up out of nowhere," Stavely says.

However, by finding and mixing groups of genes that offer resistance to large numbers of rust races, Stavely hopes to develop lines of beans that have three or four genes for resistance to each of the 28 important rust races.

Such multiple genes to resist each race will almost ensure that the disease will not adapt to something new that the bean plant cannot resist, Stavely says.

So far, the researchers have released four lines of snap bean seeds, each one having at least one gene for resistance to each race.

Resistance in snap beans was developed first because they naturally have a moderate-to-high degree of resistance to many races of fungus, Stavely says. However, most dry beans have proven "highly susceptible to 99 percent of all known races" of fungus. But the researchers are optimistic that they will eventually develop both snap and dry bean lines that have "the ultraresistance farmers need."

Meanwhile, biological control—the use of a naturally occurring organism to control a pathogen or pest of plants—may help farmers with rust and offer them an alternative to chemical fungicides.

For rust, the biocontrol organism could be a soilborne bacterium, *Bacillus subtilis,* that controls bean rust by preventing spores of the rust fungus from germinating on bean leaves.

In tests, *B. subtilis* has been 99 percent effective in the greenhouse, and 60-70 percent effective in the field. "But," Baker says, "we only achieved that level of control by spraying every few days—an expensive operation."

"The problem," Baker says, "may be caused by environmental interference with the bacterium. Or, it could be that the bacterium itself can't spread to new growth, leaving new leaves vulnerable to the rust."

Now, Baker is purifying the rust-controlling factor. He hopes to chemically modify the factor in order to improve the bacterium's effectiveness. "We may develop a fungicide that is more stable in the environment and that can spread to new bean leaves," Baker says.

Baker thinks the rust-controlling factor may be a protein. If so, it may open the door for genetic engineering techniques to produce the anti-rust protein in mass quantities.

"If we find the genes that control the production of the factor, we can transfer them to selected bacteria that can colonize and thrive on bean plants," Baker says.—**Jessica Morrison,** Beltsville, MD.

*J. Rennie Stavely and C. Jacyn Baker are at the USDA-ARS Plant Pathology Laboratory, Bldg. 004, BARC-West, Beltsville, MD 20705.* ■

Sizing bean rust-caused spots (pustules) with a grading scale is a critical aspect in determining resistance. Pustules on the underside of this leaf— more than 800 micrometers in diameter—indicate a susceptible plant. Pustules smaller than 300 micrometers indicate a type of rust resistance. (0885X874-5A)

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# PATENTS

## Mosquito Larvae Growth Inhibitors

Using growth inhibitors to control mosquito larvae can be a more effective and environmentally sound way to control the pest than using insecticides.

The growth inhibitors covered by this patent are more effective than many of the known growth inhibitors which are structurally related.

The inhibitors work by preventing most mosquito larvae from developing into adults.

A 2-year study of one of the compounds covered by the invention indicates that the compound is highly effective against mosquito larvae and harmless to fish and other aquatic organisms.

For technical information, contact Leonard Jurd, USDA-ARS Western Regional Research Center, 800 Buchanan Street, Berkeley, CA 94710. *Patent No. 4,391,828, "Dibutylorthobenzylmethoxybenzenes and Dibutylorthocinnamylmethoxybenzenes as Mosquito Larvae Growth Inhibitors."* ■

## Building a Better Boll Weevil Trap

Research for the Boll Weevil Eradication Program has led to a better boll weevil trap.

Boll weevil traps usually lure weevils through an inverted funnel into a chamber scented with a sex pheromone.

The new, improved trap works the same way, but it is built entirely with easily detachable parts. This makes it easy to build, take apart, and repair—and requires less space to store.

The addition of a ring mounted around the mouth of the funnel and a device that attaches to the ring maintains the spacing required to allow weevils to enter the funnel.

The plastic base of the trap is impregnated with a pigment that preserves its bright lemon-yellow color for at least one full season (April through October). Previously, bases were painted with a fluorescent paint that faded in the sunlight after 2 months. These traps had to be replaced when they became dull because boll weevils are attracted to bright yellow.

For technical information, contact Willard A. Dickerson, USDA-ARS Boll Weevil Eradication Research, 4116 Reedy Creek Road, Raleigh, NC 27607. *Patent Application Serial No. 734,647, "Boll Weevil Trap."* ■

## A Way to "Sniff" Out Bad Hamburger

Predicting the shelf life of hamburger can help meat buyers and sellers ensure high-quality meat.

Agricultural Research Service scientists have developed an assay technique to forecast spoilage based on the amount of lactic acid found in ground beef.

Once coarsely ground beef is reground and exposed to air, the bacterial environment changes from predominantly lactic acid-producing bacteria to the kind of bacteria that cause spoilage.

This technique would sample the beef just before it is reground and stored again. Although spoilage during storage of ground beef in air doesn't come from lactic-acid producing bacteria, the more lactic acid in the sample initially, the more severe subsequent spoilage.

For technical information, contact A. Douglas King, Jr., USDA-ARS Western Regional Research Center, 800 Buchanan Street, Albany, CA 94710. *Patent Application Serial No. 06/742,485, "Method for Predicting the Acceptability of Coarsely Ground Beef."* ■

## How to Obtain a License for USDA Patents

A listing of all U.S. Department of Agriculture patents is available on request. If you are interested in applying for a license on a patent or receiving the listing, write to the Coordinator, National Patent Program, USDA-ARS, Rm. 401, Bldg. 005, Beltsville, MD 20705.

Copies of existing patents may be purchased from the Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, Washington, DC 20231. Copies of pending patents may be purchased from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161. ■